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DEVELOPING THE STRUCTURAL USE OF NATIVE TIMBERS : IMPORTANT TECHNOLOGICAL FACTORS

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IMPORTANT TECHNOLOGICAL FACTORS

by

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INTRODUCTION

1. Factors influencing the structural use of timbers include average intrinsic strength, variability of the clear material, grade, difficulties of working, shrinkage, and others affecting jointing etc. Before the specific value of a particular species can be assessed or the relative values of a number of species determined, extensive investigations, planned to what is practicable, should be undertaken. There is a natural tendency, particularly for countries comparatively inexperienced in timber technology, to follow overseas standard procedures and specifications without question although they may not be particularly well suited to their needs. However, there is little doubt that a discussion of its special problems between an inexperienced country and more experienced countries may lead to quicker, cheaper and more satisfactory solutions.

SAMPLING PROCEDURES

2. The standard procedure, as outlined by the American Society for Testing Materials,[1] is to obtain a few logs of the species to be studied, then cut a very large number of specimens from them according to a defined pattern, and test them. In advance of final calculations, it will not be at all clear whether the result will give the properties to a precision greater or less than the minimum which is economically appropriate. If a large number of species must be tested, obviously each need be tested only to the minimum extent indicated by its value. So by a controlled total effort a greater number of species may be studied in a given time.

3. If strength properties are unknown for a large number of species, a quick approximate assessment may first be made of the potential of each, thus, for controlled development of the use of local timbers obtaining the strength properties to a precision within say ± 15% of the species mean may be a satisfactory first step. This may be done with a very small sample. In the laboratory, useful strength data may thus be obtained on as many as 30 or 40 species in the time that would be required for only one species by the old standard method. More intensive tests can then be done on specially selected species to increase the precision of estimate of the important strength properties

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[1] American Society for Testing Materials, Standard methods of testing small clear specimens of timber, A.S.T.M. Stand. D143-52 (1952).

progressively to ± 10% or ± 5%, in perhaps as little as one-tenth the testing time required with conventional species testing.

4. To achieve a particular precision the size of sample can be approximately determined in advance. From tests on a large number of Australian species it appears that if five trees are properly selected, and only one specimen for each type of test is taken from each tree, the mean values will determine the species mean properties to ± 15%, if the sample be eight or ten trees, then to ± 10%, if 24 then to ± 5%. A more precise estimate of the increase in size of sample necessary to improve the precision by a selected amount may be obtained by an analysis of the data of the first sample, and by application of the principles proposed by Pearson.[2]

5. All samples must be properly representative of the population of trees of most interest to the wood technologists and, ultimately, the timber users. The best methods of sampling are referred to by Pearson[3] and by Pearson and Williams.[3] Even where it is known in advance that a high order of the precision of the estimate of the species mean is required for particular species, the system of sampling, whereby only one specimen of each type is selected from each tree, is much less expensive than the older standard method.

STRENGTH GROUPING OF TIMBERS

6. In Australia it is found economically desirable to utilize a very wide range of timber species. Under the Australian system relatively limited technical data are sufficient to allow a fairly efficient strength grouping. Once the timber is strength grouped, there is a simple and ready basis for indicating satisfactory and not too conservative working stresses.

7. Strength groups having been established, one simple test such as density may be sufficient as a preliminary basis of strength grouping a new timber. Alternatively, a limited number of strength tests, such as bending or compression, will provide greater assurance of proper grouping and thus definition of working stresses, including those for other strength properties, with adequate degree of accuracy. Essentially, strength grouping is based on data from carefully standardized tests made on defect-free samples representative of each species. Strength-reducing defects are separately allowed for by systems of strength grading, referred to later.

8. To initiate strength grouping the mean strength properties of the weakest and the strongest timbers of all species to be included are estimated. The probable extreme range of strength of the economic structural species should then be divided into several strength groups, choice of their number being determined by use of the potential strength of each species to the maximum consistent with not excessive costs in separating, storing and selling.

9. Technically, instead of using the mean strength properties of a species, a more efficient grouping may be based on the weakest possible

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[2] Pearson, R.G., The sampling of timber for standard mechanical tests. Aust. J. Appl. Sci., 3, 25-52 (1952).
[3] Pearson, R.G., and Williams, E.J., A review of methods for the sampling of timber, For. Prod. J. 8, 263-268 (1958).

piece in the species.[4] However, a system based on the lower probability limit stress, such as the 99% lower limit value, is practicable only after the properties of a considerable number of species are known precisely enough.

10. Usually the more important strength properties are given precedence in grouping, particularly modulus of rupture, maximum crushing strength, modulus of elasticity and shear strength. According to the marketing conditions, the strength grouping may be in 2, 3 or more classifications. In Australia the groups are A,B,C and D. Most of the hardwoods fall in the first three, local and exotic softwoods in the fourth. It so happens that density is a fairly good index of these strength properties, being closely correlated with maximum crushing strength. Thus, the densest timbers tend into A, the lightest into D.

11. Frequently, in Australia, species are difficult to separate by appearance of the sawn timber. However such species from one particular growth zone tends generally to be of the same strength group as others from it.

12. Structural design with strength grouped timbers is founded on the use of working stresses independent of species in the group. To do this safely working stresses should be determined on the basis of the weakest member of the group. As technical information about particular species increases any species becoming important enough to justify separate marketing and separate working stresses can be easily dealt with independently of the grouping system.

13. The general structure of the strength groups is apparent in the modulus of rupture range (Table 1). Similar ranges are developed for the other important structural properties. Of course some timbers will not exactly fit into ranges for all properties in a strength group, because the ratios of the various strength properties differ somewhat between species. However it is usually not difficult to group them according to the most important properties.. Average basic density values for timbers in the Australian strength groups tend to follow closely the strength properties.

GRADING OF STRUCTURAL TIMBERS

14. Much of the grading of sawn structural timber throughout the world is based on studies made in U.S.A. of the effect of knots and other defects on the strength of Douglas fir. Because of cost confirmatory tests are not usually made on other species. There is now some evidence that the effects on strength of similar blemishes in hardwoods are not always the same as in softwoods. Further, the application of grading rules based on Douglas fir studies to fast-grown species of either softwoods or hardwoods may also be misleading. Rules for the grading of the species of one country may sometimes not be even reasonably efficient for the species of another.

15. Also it is not valid to deduce that the rules are safe just because structures apparently have not failed when built with timber graded to the rules. Various factors apart from grading, are concerned in the derivation of working stresses and in the structure one may compensate another. Also there is the possibility that the maximum

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[4] Pearson, R.G., Variability of timber and the derivation of design stresses, Aust. J. Appl. Sci., 3, 144-155 (1952).

TABLE 1

AUSTRALIAN TIMBER STRENGTH GROUPS

Strength Group	Modulus of Rupture lb/sq in		Density lb/cu ft	
	Green	12% Moisture Content	Green	12% Moisture Content
A	15,000	24,000	75	66
B	12,000	20,000	65	59
C	10,000	16,000	60	50
D	7,000	12,000	45	35

loads for which the structures are designed have not actually been applied. Thus, even if the allowance made for defects during grading were seriously incorrect, substantial failures may not have occurred. Even should the structure prove faulty later, it is unlikely there would then be a clear indication that improper grading was the cause.

16. Despite these difficulties, structural utilization of timber unquestionably requires establishment of reliable timber grading. However technologists should not base rules on those of another country without first finding out whether the latter have been adequately tested in practice. Moreover they must also give heed to the quantity and the quality of the trained labour available in their own country to use and administer the rules and have regard to business practice there.

17. Selected grade levels may be proportions of clear material strength which depend on the class of logs available, the proneness of the species to serious defects, and the marketing conditions. Examples are 50, 60 and 75 per cent. grades, each of which is intended to contain no piece of a strength less than the stated percentage of the strength of defect-free timber. In the early stages of selling timber of graded strength, it is unwise to complicate marketing by having more than the minimum practicable number of strength grades.

FACTORS AFFECTING THE STRUCTURAL UTILIZATION OF NATIVE TIMBERS, PARTICULARLY HARDWOODS

Density and Its Effect on Seasoning

18. Most hardwoods are considerably denser than the softwoods traditionally used for building in Europe and North America. These dense timbers dry very slowly. As a consequence, economic considerations generally lead to their use green or fairly green in construction. Nevertheless, for some uses, for example, flooring and trimming, these timbers are seasoned.

Growth Stresses

19. In hardwoods, growth stresses tend to be considerably higher than in softwoods. Growth stresses also cause splitting of logs, but the resulting loss may be reduced if the natural drying from the end of

the log is restricted by the use of a suitable coating material and the storage of logs in the shade, under water sprays or under water. Growth stresses can be particularly important and helpful in the case of timbers used in the round condition, i.e. poles and piles. However in sawn timber, they may have a serious degrading effect on strength, particularly on the timber near the centres of large trees. This "brittle heart" material is very low in impact strength, and its use structurally may lead to serious consequences. However, it is possible to separate it from the sound timber because of its different sawing characteristics, and its brittleness as shown by a knife test.

Hardness and Splitting Tendencies

21. The high density of hardwoods is indicative of increased hardness, Generally nails should be of heavier gauge than for softwoods or be hardened or of high strength.

Shrinkage Tendencies

22. Where hardwoods are used green for the framing of structures, provision must be made for subsequent shrinkage. Structural design and appropriate technique should ensure shrinkage does not cause weaknesses, instability or unsightliness of the building. Restraint to shrinkage movement across the grain may result in splitting. Special attention should therefore be given to the design of joints in green hardwood and care used in their fastening.

Creep

23. The deflections of beams under long-duration loading may increase to several times the values for short-duration loading. Due allowance for this must be made in structural timber design.

There is considerable experimental evidence that members of Australian hardwoods allowed to dry out under structural loads deflect appreciably more than those kept at constant moisture content. Their slow drying and high shrinkage require consideration of this effect. Particular attention should be given to columns as for them the amount of deflection determines the stress.

EXPERIMENTAL PROCEDURES AND RECORDS

24. Many countries are severely handicapped in obtaining the technological data necessary to exploit properly their native timbers. Suitably trained personnel are few, and testing facilities and equipment are generally limited. Yet the most expeditious assembly of necessary data is desirable, the highest efficiency necessary.

25. Testing methods have been debated by outstanding experts in world conferences. The resulting endorsed test methods, such as those published by F.A.O., should be carefully followed; so too should the most efficient sampling methods. It is very important that all testing conditions be recorded and published with the test data and that the botanical identity of all timber tested be established.

26. The determination of basic density, i.e. the oven-dry weight of a sample of timber, divided by its green volume, is recommended as the best density property for comparison of hardwood species. This avoids difficulties arising from differing shrinkage and collapse tendencies in different species.

27. Use of statistical methods in the processing of data is highly recommended, and measures of variability of that data, such as the standard deviation of individual results and the standard errors of species mean values, should be published. Only in this way can the value of the data be thoroughly assessed.

28. Every effort should be made to achieve the greatest practicable co-ordination of the technological studies of the different countries and it is highly desirable that a central technical information bureau be established for the purpose.

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